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RATIONALE FOR INTERPRETATION OF AIRBORNE DUST MEASUREMENTS AT COPPER CLIFF SINTER PLANT 1948-1963

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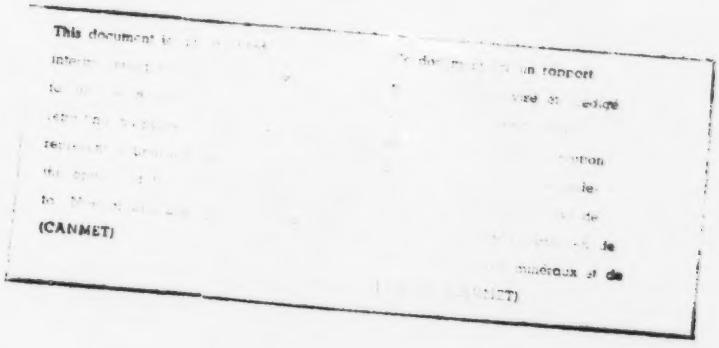

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RATIONALE FOR INTERPRETATION OF AIRBORNE DUST MEASUREMENTS AT COPPER CLIFF SINTER PLANT 1948-1963

by

G. Knight*

ABSTRACT

The factors relating to dust measurements and deposition in the appropriate physical compartments that were likely to potentiate lung and nasal cancers in workers at a nickel processing plant are considered.

Recommendations are made [illegible]stimating a first approximation for the dust exposure for correlation wi[illegible]he incidence of lung cancer, but not nasal cancer, based on the nickel concentrations determined by the roof monitors in an epidemiological study. It is argued that neither the instrumentation used, nor the instrumentation now recommended would give good relative estimates of the hazards due to nickel in this plant and in present day plants because of the large differences in dust size distribution between then and now, with resultant differences in instrument and human dust deposition, necessitating a large safety factor and/or support negative epidemiology from workers exposed to lower nickel concentration. Also given are recommendations for further studies that may be useful in refining the dust exposure estimate relevant to lung cancer and for an estimate of exposure relevant to nasal cancer.

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EXPOSÉ SUR L'INTERPRÉTATION DES MESURES DE LA POUSSIÈRE EN SUSPENSION DANS L'AIR À L'USINE DE FRITTAGE DE COPPER CLIFF 1948-1963

par

G. Knight*

RÉSUMÉ

Le rapport présente une étude sur les mesures de poussière et l'utilisation de décharges appropriées en vue d'éliminer les facteurs qui peuvent causer les cancers du poumon ou des voies respiratoires chez les travailleurs dans une usine de traitement du nickel.

On recommande de procéder à un calcul approximatif préliminaire de l'exposition à la poussière en corrélation avec le nombre de cas de cancers du poumon, sans tenir compte du cancer des voies respiratoires, en se fondant sur les résultats obtenus au cours d'une étude épidémiologique dans laquelle on a déterminé les concentrations de nickel à l'aide de détecteurs fixés au toit. On prétend que ni l'appareillage en usage dans le passé ni celui en usage actuellement ne pourraient fournir des prévisions justes quant aux risques auxquels sont exposés les travailleurs dans ces usines de nickel en raison des différences importantes qui se sont manifestées depuis dans la répartition des particules de poussière. Par conséquent les changements qui se sont produits au niveau de l'accumulation de la poussière et l'application de mesures de sécurité sévères ont concouru à enrayer les maladies des voies respiratoires chez les travailleurs exposés à des concentrations de nickel plus faibles. On recommande également de nouvelles études qui pourraient servir à préciser davantage le calcul approximatif du niveau d'exposition à la poussière lequel peut provoquer le cancer du poumon ou des voies respiratoires.

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INTRODUCTION

Roberts et al. have shown that there was an unexpectedly high incidence of lung and nasal cancers among those who worked in the Copper Cliff nickel sinter plant, which was in operation during the period 1948 to 1963 (1). Mr. Warner has discussed the dust measurements made, the operation of metallurgy, and other factors pertinent to the interpretation of the results (2).

Basics of airborne dust behaviour and physiological deposition of airborne dust can be divided into 5 classes based on physical and physiological considerations (3-5):

1. Very fine, up to 0.5 μm in size: The aerodynamic behaviour is characterized by diffusion and aggregation. Deposition in the lungs, bronchial tract, and nasopharyngeal compartment is simply represented as uniform over all surfaces, i.e., in the ratio of the effective area in each compartment. Some of the dust is exhaled.
2. Fine, 0.5 to 7 μm in size: The aerodynamic behaviour is characterized by very slow settlement under diffusional, gravimetric or inertial forces, and usually it remains airborne for extensive periods. This size range is most significant for deposition in the alveolar compartment of the lungs leading to the pneuconioses.
3. Medium, 7 to 15 μm in size: The aerodynamic behaviour is characterized by settlement in air and ready collection by inertial collectors and scrubbers. This size range is most significant for deposition in the bronchial tract compartment.
4. Coarse, 15 to 30 μm in size: The aerodynamic behaviour is characterized by rapid settlement in air, and this size is only found close to dust sources. This size range is most significant for deposition in the nasopharyngeal compartment.

5. Very coarse, 30 μm and upwards in size: The aerodynamic behaviour is characterized by very rapid settlement in air and inefficient collection by both the nose and most samplers.

DUST SAMPLER BASICS AND NASAL DEPOSITION

Nasal cancer is expected to be related to dust deposition in the nose. The nose and most samplers are variable in their efficiency of collection of dust particles in the coarse dust range. Vincent and Armbruster have studied inhalation efficiency in this size range and have proposed samplers to match human behaviour (6,7). It is clear that it is extremely difficult to estimate the nasal dust deposition from the dust measurements made. Neither the roof monitor stack sampler used at the sinter plant (RMSS), nor the sampler usually recommended at the present time, the personal gravimetric total dust sampler (PGTDS), gives an estimate of the airborne dust that would enable calculation of nasal deposition. Recent tests in high concentration coarse dust clouds in potash mines have shown 4 to 1 differences between open face and closed face 'total' dust samplers (8).

The RMSS is usually used in a near isokinetic condition and would give reasonable measurements of the coarse dust presented to it. In the sinter plant, however, the coarse dust was largely elutriated from the rising air and therefore not measured.

The differences between the RMSS and PGTDS tests carried out in high concentrations of dust, presumably containing a significant quantity of coarse dust (2), in which the RMSS indicated a five times higher dust concentration than the PGTDS, probably arose due to differences in the collection efficiency of coarse dust by each instrument. Neither instrument could be relied on in these undefined coarse dust concentrations and air movements to be indicative of relative nasal deposition, or to be indicative of their behaviour in other

ambient conditions. One possible approach to estimating coarse dust exposure (nasal deposition) could start with a measurement of the size distribution of the settled dust found on the fixed structure and the historical rates of deposition, followed by a theoretical analysis. The size distribution should be estimated in terms of aerodynamic size.

DUST SAMPLER BASICS AND LUNG DEPOSITION

Lung cancer presumably arises following deposition of dust in one or more of the three dust fractions; very fine, fine, and medium, in the alveolar and or bronchial tract compartments. It is expected that both the RMSS and the PGTDS would give a reasonable estimate of the sum of these three fractions under most sampling conditions as long as coarse dust is not present. The comparisons carried out in low dust concentrations support this expectation (2).

Thus, it can be expected that the RMSS gave a reasonable estimate of the dust likely to induce lung cancer, that was present in the air approaching them. However, this differed from the dust presented to the workers in three significant ways:

1. Dilution by air entering the upper windows probably meant that the roof monitors indicated significantly lower dust concentrations than were, on average, present at the working levels.
2. Elutriation of the coarser particles in the size range of interest from the air slowly rising to the roof monitors.
3. The variations of dust concentrations from working place to working place. The mean levels at the working places could have been higher or lower than the mean from the roof monitors after correction by (1) and (2) above, depending on the distribution of working places over the plant.

Factors (1), (2) and (3) are probably very much larger than the

possible differences between the RMSS dust sampler then used, and the PGTDS dust sampler, which is now the recommended instrument.

EFFECT OF DUST SIZE DISTRIBUTION ON DUST STANDARD

The Committee for Threshold Limit Values for Airborne Contaminants in the Working Place, suggests that a total dust sampler should be used for assessment of the potential health hazard of nickel (9). It has to be appreciated that the sampler does not, in general, accurately indicate the relative hazard of dust clouds with widely differing size distributions because of the corresponding changes in relative deposition in the various compartments of the human respiratory system.

In attempting to derive epidemiological support for the present 1 mg/m^3 nickel TLV from the cancer incidence in the Copper Cliff sinter plant, where the estimated total dust concentrations were of the order of 100 mg/m^3, consideration has to be given to the very large change in dust size distribution that also occurred. It is highly probable that the historic dust cloud contained 75% or more of its weight in particles larger than those found in dust clouds meeting the 1 mg/m^3 standard nowadays, and that the 100:1 reduction in total dust corresponds to only a 10:1 reduction in respirable dust.

It is not clear, at least to my understanding, as to the relative potential for cancer initiation of nickel containing dust particles of different sizes deposited in the different compartments of the respiratory system. A substantial safety factor should be used, therefore, if the Copper Cliff sinter plant epidemiology is all that is available. It is also very

important to include epidemiology from other plants with substantially lower nickel concentrations.

RECOMMENDATIONS

1. The roof monitor stack sampler dust measurements should be used as a first approximation to estimate dust exposures for the sinter plant workers and as a basis for a correlation between dust exposure and lung cancer.
2. The single dust measurement in 1948 seems to be anomalous and in the period from opening to full operation it is expected that each line was dusty and its operators were close to the machine, thus, they were exposed to the dust levels determined in the 1950 survey. If construction workers on the non-operating lines are included in the cohort, it might be more rational to allocate to them the 1950 dust levels multiplied by the number of lines operating divided by the total number of lines.
3. Prior to carrying out further extensive studies, the safe working level based on the above epidemiological study should be compared with the present threshold limit value. If there is an apparent substantial safety factor, then the factors of elutriation and variability need only to be shown to be very unlikely to be less than the safety factor.
4. A size distribution measurement of the settled dust should be made, followed by a theoretical computation of the dust cloud giving rise to such settlement.
5. Estimates should be made of the nasal deposition and the additional potential lung deposition resulting from the modelled coarse dust cloud determined in (4). The dust cloud should be truncated on the low side at the calculated elutriation size for the air rising to the roof monitors when calculating additional lung deposition.

6. Dust sampler comparisons between the RMSS and PGTDS in coarse dust clouds should be carried out in controlled conditions:

   a) The comparisons carried out previously in high concentrations (2) could be repeated with a vertical sampling duct arranged to simulate the vertical air velocities calculated for the CCSP building with appropriate section changes. Sampling with the RMSS would be carried out in the highest reduced section. Sampling with the PGTDS would be carried out in the upper and lower sections as well as outside in the belt enclosure.

   b) Laboratory comparisons could be carried out in a test tunnel where air velocities and orientations can be controlled. The Elliot Lake Laboratory is intending to build such a facility in its new laboratory, possibly available in 1986. McGill University at present has such a facility.

7. If a suitable site can be found in a hot process plant, comparisons could be made between RMSS measurements at exhaust stacks and the PGTDS and inhalable dust sampler measurements near the dust sources. It is probable, however, that such measurements would not be applicable without confirmation of (4) above.

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